

SCIENCE AND TECHNOLOGY PROGRAM

SUCCESS STORIES

MAKING THE WESTERN U.S. POWER GRID MORE COST EFFECTIVE AND RELIABLE

IMPROVING POWER RELIABILITY AND REVENUES

Science and Technology (S&T) research has determined that the value of specialized power products provided by Reclamation powerplants, such as the reserve power services, are worth millions of dollars to the power industry. Grand Coulee and Hoover Powerplants provide about \$100 million per year worth of specialized power projects. Maximizing these specialized power products will further increase the reliability and cost effectiveness of the power grid in the Western U.S.

IMPROVING POWER RELIABILITY

S&T research has helped to improve equipment and techniques that prevent major, costly power failures (blackouts) for the past 30 years. These technological advancements have also been formally and informally transferred to the private sector, benefitting the entire nation. Recent contributions have included a digital governor that more reliably and effectively governs the generator speed. Woodward Governor has assisted with industry-wide deployment through a Cooperative Research and Development Agreement.

KEEPING POWERPLANT WORKERS SAFE

INCREASING SAFETY AND REVENUES

S&T research helped to develop a tunnel communication system that allows work crews in long tunnels to communicate with crew members on the outside. This vital communication link greatly improves worker safety, saves time and money as tunnel inspections and repairs are much simpler, and increases power revenues since it is now possible to clean the power tunnel more frequently. Increased additional power revenues resulting from initial deployments on several tunnels in the Upper Colorado, Mid-Pacific, and Great Plains Regions are estimated at \$2,000,000.

INCREASING SAFETY

S&T research led to developing a new safety device, the rotor turning gear. The rotor turning gear improves worker safety and makes it easier to perform the hazardous task of slowly turning large hydroelectric generator and motor rotors for inspections and repairs. Power facilities in Reclamation and Ontario Power are interested in the device. Deployment efforts will follow.

KEEPING POWERPLANT EQUIPMENT RUNNING SMOOTHLY

DEVELOPING COST-EFFECTIVE AND ENVIRONMENTALLY FRIENDLY POWERPLANT REHABS

S&T research into high-voltage generation has helped evaluate a promising technology (Powerformer™) to make powerplant rehabilitation more cost effective. Using this technology instead of conventional rehabilitation methods extends the life cycle of the equipment, reduces maintenance requirements, and eliminates environmental risks from transformers. Initial deployment is being considered at Folsom Dam.

INCREASING POWERPLANT EFFICIENCY AND EFFECTIVENESS

S&T research advanced modular Supervisory Control and Data Access (SCADA) systems to lower overall life-cycle costs and enable new developments in technology to be readily incorporated without major and costly system rehabilitations. Five facilities, including Hoover Dam and Central Valley Project facilities, now use the modular SCADA systems.

LEADING INDUSTRY TO REPAIR CONCRETE, EVALUATE DAMS, AND ADDRESS CORROSION

EXTENDING THE LIFE OF OUR STRUCTURES AND SAVING MONEY

S&T research developed concrete repair technologies that are now industry standards. These repair technologies, published in Reclamation's *Guide for Concrete Repair*, are the foundation for all concrete repairs specified on Reclamation facilities and other Federal agencies such as the U.S. Forest Service, Bureau of Land Management, and U.S. Fish and Wildlife Service. Through these repair techniques, Reclamation avoids rebuilding, which saves millions of dollars and can easily double or triple the life of a repair over previous repair methods.

ADDRESSING CORROSION

S&T corrosion research helped Reclamation successfully address corrosion issues associated with prestressed-concrete siphons on the Central Arizona Project.

EARLY DETECTION OF PROBLEMS AND SAVING MONEY

The S&T research developed nondestructive technologies to evaluate the internal condition of large concrete dams, spillway gates, spillway slabs, and measure in-situ stresses in bridge decks. S&T works with various Area Offices to develop and use these technologies, and applies these technologies to other Reclamation projects. These technologies have cut the cost of on-site assessments by as much as 80 percent. Advanced detection and more targeted repair locations improve facility assessments reliability and reduce the cost of some repairs by over 50 percent.

BATTLING EROSION AND CAVITATION

PREVENTING EROSION

S&T research developed erosion-protecting blocks—a low-cost alternative to protect low-head dams and other water conveyance features during floods. An articulated mat of individual overlapping blocks paves the flow surface to protect the facility during damaging flow conditions. The blocks dissipate the energy of the flows while water forces help hold the blocks in place. Reclamation worked with ARMORTEC (www.armortec.com) to commercialize this product and provide a reliable manufacturing service for Reclamation and others.

PREVENTING COSTLY DAMAGE TO STILLING BASINS

Rock and debris entrained in stilling basin flows continually damages concrete stilling basins at 38 Reclamation facilities and many other non-Reclamation facilities. Repairing this damage can cost several hundred thousand dollars, require costly facility downtime, and require frequent underwater inspections to monitor damage. Depending on the site, significant damage can occur in less than 5 to 10 years.

S&T is demonstrating a device on Mason Dam to prevent this costly scour erosion to stilling basins. The new device is a flow deflector vane—similar to an air foil on the back of a race car—to tame the surging water flows.

PREVENTING COSTLY CAVITATION DAMAGE TO WATER DELIVERY FACILITIES

Just as a tornado creates a vacuum in a building and causes it to implode, high velocity water flowing over small bumps on the surface of water delivery features can create a powerful vacuum that causes significant and costly damage from cavitation. Cavitation occurs when flowing water becomes separated from the surface of pipes, turbines, chutes, valves, and other water delivery features.

S&T is developing acoustic monitoring technology designed to detect cavitation problems early. Facility operators would be able to hear cavitation occurring so that operations can be adjusted before costly damage and downtime for repairs occur. S&T has also helped develop anti-cavitation valves and spillway chute features for retrofits and upgrades.

TRANSPORTING AND MEASURING WATER MORE EFFECTIVELY

SAVING WATER AND WATER QUALITY WITH IMPROVED WATER SUPPLY TECHNOLOGIES

Many of the irrigation projects in the Western U.S. either don't have measurement devices or have ineffective devices which need a lot of maintenance. S&T research has made significant advances during the past 4 years in low-cost flow measurement technology coupled with remotely monitored and operated canal capabilities. S&T partnered with many others to develop the WinFlume technology, which is now the water measurement tool of choice in the U.S. and abroad.

These advances improve water delivery efficiencies from about 65 percent to about 80 to 95 percent. On a project diverting 150,000 acre-feet per year, these simple and affordable technologies could save 30,000 acre-feet per year. The value of these savings would be \$4.5 million for a single project when water costs are \$150 per acre-foot. These advances also increase operational flexibility and crop production and decrease operation efforts and water quality and salinity impacts. Deployments have progressed on projects in the Snake, Yuma, Montana, Provo, and Albuquerque Area Offices.

EXTENDING THE LIFE OF CANALS, CONSERVING WATER, AND SAVING MONEY

S&T partnered with the Pacific Northwest Region, 20 geosynthetic manufacturers, and 10 irrigation districts to research and develop low-cost canal lining systems that irrigation districts can easily install. Thirty-five test sections have been constructed using combinations of membranes, geotextiles, shotcrete, soil, coatings, and sprayed-in-place foam. The Tule Lake Irrigation District recently lined their canals with these new products to conserve water in the Klamath Basin.

Cost/benefit analysis has shown that every \$1 spent on canal rehabilitation can return \$3 to \$5 in conserved water, and that every \$1 spent on canal lining maintenance can return up to \$10 in conserved water. With over 16,000 miles of canals, many unlined, serving Reclamation project lands—savings could be significant.

CONTROLLING THE COST AND IMPROVING THE RELIABILITY OF WATER DELIVERIES

S&T partners with Reclamation Area Offices and other agencies to research aquatic habitat and fish protection for species that could impact Reclamation operations. The knowledge gleaned from this research helps enhance operational decisions that can reduce impacts to fishes while continuing contract water deliveries. The program has also made advances in preventing fish entrainment and promoting fish passage.

Others also recognize the value of S&T research as other Federal agencies (including the U.S. Fish and Wildlife Service, National Marine Fisheries Service, Corps, and National Park Service), state fish and game agencies (including nearly every state in the Western U.S.), and many private water districts and engineering companies request assistance and partner with us.

Without S&T Program investments, we would not have today's innovative fishery structures, including:

- *Marble Bluff Fish Lock*— A major success story for protecting endangered cui-ui suckers.
- *Huntley Diversion Dam rock channel fish pass* — A natural channel design for native fish.
- *Intake Diversion Dam Fish Passage for sturgeon* — Research is underway to support this and other sturgeon passes at diversion dams on the Yellowstone and Sacramento Rivers.
- *Klamath Falls, Link River Dam Fish Pass* — Research helped design a second generation Reclamation fishpass for sucker species.
- *Derby Dam Fish Way* — A natural channel fishway based on prototype laboratory research of rock channel fishways for cui-ui suckers and Lahonton Cutthroat Trout (both listed species) will be built in 2002.
- *San Acacia Diversion Dam* — Research is ongoing to develop fish passage capability for silvery minnows native to the Rio Grande.

Recent work has focused on the Yakima basin in the Pacific Northwest Region and the Bay-Delta in the Mid-Pacific Region. These unique field laboratories allow us to not only solve problems at these locations but advance knowledge and technologies to apply at other locations.

Developing a specialized screen to remove mitten crabs from Reclamation diversions out of the Delta is another example. This successful screening allowed us to continue to protect endangered and listed species while continuing water deliveries to southern California and the Central Valley Project that are valued at over \$1 million per day. Other diversions are now using this specialized screen concept to sort fish and remove debris.

TREATING INVASIVE SPECIES EFFECTIVELY WITHOUT HARMING THE ENVIRONMENT

SAVING WATER BY BEATING SALT CEDAR

Salt cedar clogs waterways and consumes more water than native vegetation. The menace has invaded most riparian areas of the arid Western U.S., using as much as 2.5 million acre feet of water a year. Estimates of the annual dollar value from lost irrigation water are as high as \$288 million, and the annual dollar value from lost power generation along the Colorado River alone as great as \$43.5 million. The S&T Program, in collaboration with U.S. Department of Agriculture and other agencies, has made significant progress in demonstrating potentially effective methods to eradicate salt cedar with insects that eat only salt cedar. An insect release demonstration site along the Arkansas River—the first major test to prove this potentially effective, low-cost, and environmentally friendly method of eradication—started in 2001.

S&T has used similar insect control techniques to eradicate purple loosestrife, which clogs other Western waterways. At an S&T demonstration site on the Winchester Wasteway in the Upper Columbia Project in Washington, purple loosestrife was totally eradicated. This program produced more successful results than the alternative: harmful herbicides that would cost over \$100,000 and require additional stringent NEPA compliance.

INVESTIGATING AND IMPROVING WATER QUALITY

MORE RELIABLE AND LESS COSTLY WATER QUALITY INVESTIGATIVE TECHNIQUES

S&T is customizing cutting edge remote sensing technology for Reclamation's specific needs to quickly, reliably, and more accurately investigate and monitor reservoir water quality. These technologies have recently been used to successfully detect and map *chlorophyll-a* concentrations, turbidity, and water surface temperature variations. Future work focuses on detecting heavy metals, bacteria, various species of algae, and other pollutants. These

technologies provide more complete and accurate water quality mapping at half the cost and half the time than more conventional manual methods. This accuracy and rapidity can help protect the health and safety of hundreds of thousands of people.

IMPROVING WATER QUALITY

S&T research has been instrumental in improving selective reservoir withdrawal techniques to meet water temperature standards for endangered species below Shasta, Hungry Horse, Flaming Gorge, Folsom, and other dams. Before 1997, Reclamation had to spill cold water through Shasta Dams's low-level river outlets instead of through the power house. A unique selective withdrawal system, using knowledge gained through the S&T Program, now provides the required water temperature for fish while continuing releases through the powerplant to generate more electricity. In January 2002, the Shasta Temperature Control Device received the National Hydropower Association's Award in the Technological Solutions category. This award is given to projects that demonstrate significant contributions to the hydropower industry in licensing, engineering, construction, hydraulics, dam safety, land use, operations, maintenance, and/or economic use.

CREATING NEW SUPPLIES THROUGH DESALINATION AND WATER TREATMENT

ENHANCING WATER SUPPLIES THROUGH WATER TREATMENT

- Partnered with Tucson Field Office and four local water providers to pilot test and demonstrate slow sand filtration (SSF) and reverse osmosis (RO) water treatments to purify and desalt Central Arizona Project (CAP) water. Successful pilot test results of nontraditional water treatment technologies once more demonstrate the success of our S&T-Technical Service Center-Area Office-local groups partnering.
- Refurbished Army surplus reverse osmosis water purification unit to develop and demonstrate cost-effective, portable, 600-gallons-per-hour water supply for the Kickapoo Tribe along the Rio Grande River.
- Optimized treatment and disinfection processes applied to the Mni Wiconi Water Treatment Plant that will bring 8 million gallons per day from the Missouri River to the Lower Brule, Redbud, and Pine Ridge Indian Reservations in South Dakota.
- Published the *“Desalting and Water Treatment Membrane Manual: Guide to Membranes for Municipal Water Treatment”* (2nd Edition) in 1998, which transfers membrane softening, ultrafiltration, and microfiltration technologies to the municipal water treatment industry. Requests for this document come from all over the world.

- Published the “*Water Treatment Primer for Communities in Need*,” which helps transfer water treatment technologies developed for small and Native American communities with impaired or inadequate water supplies. The manual enables communities in need to become more proactive in solving their water quality problems and move toward improving their drinking water quality.
- Developed, demonstrated, and deployed solar powered water treatment technologies as an economical alternative water supply for Native American and rural communities that are off power grids and water supply networks. The demonstration has led to delivering 1,000-gallons-per-day of safe drinking water to the Navajo Nation. The technology is now being considered to provide water supplies to portions of the Mni Wiconi Project.
- Reclamation is now recognized as a major clearinghouse for desalination research and technology in the United States as a result of our long desalination research legacy and research conducted under the Water Desalination Act of 1996. The information clearinghouse helps to deploy by applying more efficient products and processes to increase the quantity and quality of water available to the American public and water scarce regions of the world.
- Developed innovative, high pressure, seawater pump that significantly reduces energy consumption and dramatically improves seawater desalination. The system uses 50 percent less energy than conventional reverse osmosis systems and 90 percent less energy than multi-stage flash distillation. In California, large amounts of energy are used for trans-basin movement of water. High energy recovery with seawater desalination can provide a new supply of water at an energy cost less than that of transbasin distribution.
- Demonstrated reverse osmosis and nanofiltration water treatment systems at McAllen, Texas, enabled the city to proceed with deployment of a 1-million-gallon-per-day system to treat wastewater. The system will enable McAllen to recirculate the treated wastewater to their drinking water, which will allow them to reuse their scant Rio Grande allocation three or four more times.

WORKING WITH CUSTOMERS TO IMPROVE MANAGEMENT PRACTICES

INCREASING WATER SUPPLIES THROUGH BETTER MANAGEMENT PRACTICES

S&T research is evaluating water management practices at a variety of water and irrigation districts and practices recommended by water resource organizations. Best practices and lessons learned are identified and shared with water districts in a workshop environment. This has proved especially beneficial to help optimize practices in the face of increasing demands on

agricultural operations from urbanization and other challenges. Provided recent workshops to irrigation districts served by the Provo Area Office. These resulted in standing room only crowds and requests for additional workshops.

Dr. John Wilkens-Wells at Colorado State University has been leading this research project for the S&T Program. He received the Four-State Irrigation District Headgate Award in 1999 for the contributions this research has made to the agricultural community.

GETTING THE INFORMATION YOU NEED TO OPERATE EFFECTIVELY

IMPROVING RESERVOIR AND RIVER SYSTEM OPERATIONS - DECISION SUPPORT

Watershed and reservoir decision support modeling developed under the S&T Program are now standard operation modeling tools on many Western river systems. The models help evaluate trade-offs between various operating scenarios and competing demands to optimize water deliveries with available supplies. These tools provide the water managers with multi-objective water management decision support models using emerging technologies and real-time watershed and river system data to help stretch existing water supplies to meet competing demands.

Water storage decision support models include precipitation, snowpack, and water storage using a watershed and river system approach. Water demand models include legal constraints, power, municipal, recreation, aquatic habitat, and agricultural crop demand. Evapotranspiration and other system loss models are also included. These models can be used independently or linked to RiverWare or other operational decision support systems to provide integrated, near real-time water management decision support.

S&T partnered with Reclamation projects to develop watershed and river system management technology. Recent implementations and payoffs include:

- Provided daily Middle-Rio Grande riparian and crop consumptive use forecasts. The Albuquerque Area Office management used these in Federal District Court to help assure the Judge that Reclamation was doing its best by using advanced technologies to keep water in the river for the Endangered Species Act-listed silvery minnow. Products from Agricultural Water Resources Decision Support (AWARDS) and Evapotranspiration (ET) Toolbox were extremely helpful in making daily decisions regarding water releases to optimize water deliveries during time of drought. Steve Hansen, the Deputy Area Manager in Albuquerque, has complimented the team for outstanding support of his operations.

- Improved consumptive use estimates for phreatophytes and crops on the mainstem of the Colorado River in the Lower Basin. This data is critical to more accurately account for water use on the river and determine water use by the phreatophytes.
- Successfully demonstrated simulations and applications of water operations and accounting in the Upper Rio Grande in 2001 to assist in delivering water under drought conditions to irrigators while keeping critical reaches of the river wet for the silvery minnow. This technology was developed jointly by S&T funding and the Upper Rio Grande Water Operations Modeling (URGWOM) effort. The RiverWare planning model will be a key tool of the Upper Rio Grande Water Operations Review Environmental Impact Statement and studies of operational alternatives towards maximized conservation while serving the water owners, environmental needs, and recreational benefits.
- Used URGWOM's RiverWare based Water Operations Model to formulate informed operations days to months ahead successfully produced the 2001 Rio Grande Annual Operations Plan. Timely presentation of this report is a valuable service to Reclamation's partners and customers, informing all to make the best decisions towards meeting needs while conserving resources. This model will be used on a daily basis starting in 2002 to help make the best operational decisions to most effectively deal with drought and competing water demands.
- Used RiverWare modeling capability developed under the S&T program to successfully analyze the Colorado River Basin for the Interim Surplus Guidelines Environmental Impact Statement. Partnered with the Upper Colorado and Lower Colorado Regions. This was a major milestone in Colorado River Basin work to better manage the water supply. Beneficiaries include all users of the Colorado River—especially the seven basin states, other Federal agencies, Reclamation's stakeholders, and environmental and recreational groups.
- Developed RiverWare tools to complete analysis for the Colorado River Implementation Agreement Environmental Impact Statement and the Multi-Species Conservation Plan. This work is critical to completing the California Plan required actions by the end of December 2002 and Endangered Species Action compliance for operations and maintenance activities.
- Improved high resolution quantitative precipitation estimates from radar precipitation accumulation algorithms (PAA) over the Upper Missouri Basin and Colorado River Basin watersheds. These estimates, developed under the S&T Program, are provided in near real time on the Internet for water operations managers.
- Improved water supply forecasting of reservoir and river system inflows can prevent excessive spills and enable better use of flood control and water conservation pool space.

INCREASING OPERATIONAL EFFICIENCY AND IMPROVING RISK MANAGEMENT

Throughout the 20th century, engineers designed and operated dams without the luxury of present-day hydrologic science and information. Conservative operating scenarios and estimates of extreme flood events were needed to ensure the safe construction and operations of dams. The S&T Program is developing a Stochastic Event-Based Flood Model (SEFM) which can economically produce a range of probabilistic flood hydrographs for various combinations of site-specific conditions. Results have already been used as input to dam safety risk assessments. Future potential benefits to Reclamation include the ability to more confidently reallocate reservoir surcharge space to active conservation storage. The additional space can provide water for environmental and other uses while still maintaining a safe dam. As such, these more modern, reliable flood estimates may eliminate or minimize the need for enlarging many dams in the future. We are also working with the National Weather Service and other agencies to evaluate and update precipitation data and the methods to better incorporate historical precipitation records and trends in the prediction of large and operational flood events.

In addition, S&T is working to improve forecasting for reservoir and river system inflows to prevent excessive spills. Upper Colorado River water operations managers determined that the National Weather Service's underprediction of June 1999 inflows at Flaming Gorge resulted in spilling over 210,000 acre-feet valued at over \$1 million in hydropower generation and \$2.1 million in lost water storage.

PROTECTING CULTURAL RESOURCES WHILE SAVING MONEY

LOCATING ARTIFACTS AND ANCIENT STRUCTURES MORE RELIABLY AND AT LESS COST

S&T is partnering with the Upper Colorado Region to use non-destructive prospecting technologies to locate buried prehistoric historic and structures. These new technologies can prevent the cost of inadvertent damage to ancient structures and cultural artifacts during construction which can easily exceed \$100,000 per incident as well as save the cost of prospecting with a backhoe and archeological crew.